# Multi-Scale Meshes for Finite Element and Finite Volume Methods: Active Device and Guided-Wave Modeling

Tom Cwik, Roberto Coccioli *, Greg Wilkins**, John Lou and Charles Norton

Jet Propulsion Laboratory

*UCLA, Electrical Engineering

** Morgan State University, Electrical and Computer Engineering

Multi-scale electromagnetic field problems consisting of small regions with highly confined fields or charges adjacent to larger open regions where the fields are more smoothly varying are under consideration in several areas. Active devices, consisting of thin doped layers adjacent to bulk material layers are used in current millimeter-wave systems that include sensors or communication functions. Similarly, guided-wave structures consisting of thin ferroelectric substrates are used for permittivity control in integrated circuit structures and in phase shifters for phased array applications. The models for these devices are typically non-linear and may involve the coupling of carrier transport and electromagnetic field equations or they require the ability to account for significant variation of material permittivity in fine regions. The means of solution involves using finite volume or finite element methods solved on grids that require multi-scale meshes over regions of the device or waveguide, and also with different scales between Boltzman's transport equations and Maxwell's equations.

This talk will examine the application of an adaptive mesh refinement library for the generation and control of a multi-scale mesh. The library will be used to adaptively refine a given coarse mesh through multiple levels to produce a mesh with the gradations necessary to model the field variations within the device or guided-wave structure with the desired accuracy. The initial mesh contains all geometry and boundary condition information, along with regions that need the multi-level refinement. The adaptive mesh refinement library used contains mesh quality control algorithms to limit the range and number of distorted elements produced. This step is essential in producing mesh elements with limited distortion. The meshes produced are used in finite volume solutions to the coupled Boltzman-Maxwell Equation transistor model consisting of a thin doped layer under the contacts, and adjacent to larger bulk buffer layers. They are also used in a guided-wave structure consisting of a thin ferroelectric film supporting conductors in an inhomogeneous waveguide structure.